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OIL AND ENERGY DEMAND IN DEVELOPING COUNTRIES IN 1990

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How much of the world's oil and energy supply will the non-OPEC less-developed countries (NOLDCs) demand in the next decade? Will their requirements be small and thus fairly insignificant compared with world demand, or large and relatively important? How will world demand be affected by the economic growth of the NOLDCs?

In the study on which this paper is based, we try to develop some reasonable forecasts of NOLDC energy demands in the next 10 years. Our focus is mainly on the demand for oil, but we also give some attention to the total commercial energy requirements of these countries. We have tried to be explicit about the uncertainties associated with our forecasts, and with the income and price elasticities on which they are based. Finally, we consider the forecasts in terms of their implications for U. S. policies concerning the NOLDCs, and suggest areas of future research on NOLDC energy issues.

FORECASTING NOLDC ENERGY DEMAND

In 1976, total commercial energy consumption (including oil, gas, coal, and primary electricity) by all NOLDCs amounted to 9.3 million barrels per day (MB/D) in oil equivalent, or about 11.5 percent of global consumption, excluding the centrally planned economies. Oil consumption (excluding petrochemical feedstocks) by all NOLDCs in 1976 was 5.6 MB/D, or about 14 percent of the global figure. Oil imports by NOLDCs in 1976, were about 15 percent of world imports.

Distribution of these total figures among the upper-income, middle-income, and lower-income NOLDCs is shown in Table 1.

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*The study is reported more fully in "The Demand for Oil and Energy in Developing Countries," R-2488-DOE, The Rand Corporation, May 1980.

Table 1

Energy and Oil Consumption and Imports, 1976:   Non-OPEC
Less-Developed Countries (NOLDCs)
(in million barrel/per day oil equivalent)

	Commercial Energy Consumption[*]	Oil Consumption[*]	Oil Imports[*]
1. World[**]	80.5	39.2	30.6
2. Non-OPEC LDCs	9.3 (11.5%)	5.6 (14.3%)	4.7 (15.3%)
3. Upper income NOLDCs	4.8 (6.0%)	3.7 (9.4%)	2.9 (9.5%)
4. Middle income NOLDCs	1.8 (2.2%)	1.2 (3.1%)	1.1 (3.6%)
5. Lower income NOLDCs	2.7 (3.3%)	0.7 (1.8%)	0.7 (2.1%)

Source: World Energy Supplies, U. N. Series J, 1978. Following past
World Bank studies, NOLDCs are divided in three groups by
per capita income in 1972: higher income countries are those
above $375, lower income countries below $200, and the middle
income group between the two.

[*]Figures in parentheses show shares of corresponding world figures.

[**]Excluding centrally planned economies.

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Several estimates, summarized in Table A in the appendix, have
previously been made of future NOLDC oil and energy consumption.

The models on which our forecasts are based express current demand as a
function of current income and price, measured in constant units, and of
demand in the immediately preceding period.[*]

$$\text{Model 1:} \quad Q_{i,t} = a_o (Y_{i,t}^{\alpha} P_{i,t}^{\beta})^{1-\lambda} Q_{i,t-1}^{\lambda} \tag{1}$$

Q = energy (or oil) demand (in millions of barrels of oil)

Y = gross domestic product (in constant units)

P = energy prices (in constant units)

i = 1,2 ..., 77 (non-OPEC less-developed countries)

t = 1967, ..., 1976

λ = geometric adjustment lag, $(1 \geq \lambda \geq 0)$. (A low value for λ implies
  that actual demand adjusts rapidly to income and price changes, and
  hence desired demand is realized quickly; the converse is implied as λ
  approaches unity).

α, β = long-run income and price elasticities, respectively.

$$\text{Model 2:} \quad Q_{i,t} = a_o (P_{i,t}^{\beta})^{1-\lambda} Q_{i,t-1}^{\lambda} Y_{i,t}^{\alpha_1} Y_{i,t-1}^{\alpha_2} \tag{2}$$

The second model assumes that demand adjusts co GDP directly, without
intercession of the lag factor, $(1 - \lambda)$.

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[*]For further discussion of the models, and their theoretical basis, see
Rand report R-2488-DOE, op. cit.

Our forecasts of NOLDC demand for the next decade cover an extremely wide range. For example, in our forecast of NOLDC oil demand in 1990, there is more than a threefold difference between our minimum of 5.73 MBD and our maximum of 17.45 MBD. As a share of world oil demand, these figures correspond, respectively, to a minimum between 7.8 percent and 10.6 percent, and a maximum between 23.5 percent and 32.2 percent. The NOLDC portion of the forecasted world oil imports in 1990 may be as small as 8.3 percent, or as large as 34.6 percent, assuming that the 1976 relationship between oil imports and oil consumption still prevails in 1990.[*] These figures are summarized in Table 2.

Table 2

Forecasts of Amount and Shares of NOLDC Oil Consumption in 1990

	Amounts of Shares	
NOLDC Oil Consumption in 1990	Rand Forecasts	Previous Forecasts
Total oil consumption	5.7-17.4 MB/D	10.0-13.5 MB/D
Consumption as a share of world oil consumption	7.8-32%	14.4-24.5%
Imports as share of world oil imports	8.3-34.6%	15.5-26.5%

The wide range of our forecasts for NOLDC oil demand in 1990 reflects the substantial uncertainty attendant to such forecasts. In addition to the standard errors of the forecasts, there are three principal sources of this

*The range of the minimum and maximum percentage shares depends not only on the range of our estimates of NOLDC consumption (or imports), but also on whether we use the high (74 MB/D) or low (54 MB/D) estimates of world oil consumption in 1990 that have been made in other studies. For details, see ibid.

uncertainty: (1) differences in scenarios assumed for NOLDC economic
growth and for world oil prices; (2) differences in the definition and
measurement of variables used in the models; and (3) differences in model
specifications. Among the three, differences in scenario assumptions and
in the definition of variables have about equally large effects, whereas
differences in model specification have the smallest.

Differences in the scenarios (covering the high income growth
--7% per annum--and slow price growth--3% per annum--and the slow income
growth--3% per annum--and rapid price growth--5% per annum--scenarios)
account for a 43% variation in the forecasts. Of course, this range would
be widened further if the scenarios were expanded to allow for more
extreme income growth and price scenarios that could be created by various
political and technological contingencies: for example, contingencies due
to political instability or disruption in the Middle East, or contingencies
relating to new major oil discoveries or to technological breakthroughs or
breakdowns in the development of synthetic fuels.

As noted earlier, there are several plausible ways of measuring,
deflating, and adjusting the income and price variables of the models.
These alternatives are another major source of uncertainty. Differences
in the definition and measurement of the price and income variables, while
the scenarios and model specifications are held constant, account for a
variation of more than 53% between the high and low forecasts for 1990.

By way of contrast, differences in model specification result in a
maximum difference of only 5.2 percent between the estimates of model (1)
and model (2) for any given scenario.

These results, relating to the different sources of uncertainty and
their relative effects, are summarized in Table 3.

Table 3

MAXIMUM VARIATION DUE TO EACH SOURCE OF UNCERTAINTY

Source of Uncertainty	Maximum Variation (%)
Scenarios	43.3
Definition of variables	53.5
Model specification	5.2

The income and price elasticities with which our demand forecasts are
associated are correspondingly wide. The apparently simple question,
"What is the income (or price) elasticity of demand for oil or energy in the
NOLDCs?" admits of neither a simple nor singular answer. Using regression
equations we have calculated four different types of elasticity (i.e., short-
run, medium-run, long-run, and "realized by 1990"), which vary by a factor
of five or more across the four types. In general, our income elasticities
are appreciably lower than those calculated in previous studies, but our
price elasticities are similar to previous estimates.[*]

The NOLDC forecasts, in barrels per day and as a share of world demand,
are shown in Tables 4 and 5, together with the ranges and sources of
uncertainty in these estimates.

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[*]The original regression equations from which these elasticities were
derived are shown in Appendix Tables B and C. The four different types
of elasticity estimates are shown in Appendix Tables D and E.

Table 4

PERCENTAGE RANGE OF OIL DEMAND FORECASTS

4.A Range Due to Forecast Standard Errors

Country Dummies	Adjustment to Income Change	Dependent Variable Form	Growth Rates (%)		Range of Forecasts and Share World[a] Demand		
						1990[b]	
			GDP	Price	Mb/d	(%) WAES	(%) Eden
Absent	Delayed (Model 1)	Aggregate	3.	5.	7.07 9.61	10.-13.	13.-18.
			7.	3.	8.93 12.14	12.-16.	17.-23.
		Per Capita	3.	5.	6.81 9.06	9.-12.	13.-17.
			7.	3.	9.57 12.73	13.-17.	18.-24.
	Immediate (Model 2)	Aggregate	3.	5.	6.75 9.07	9.-12	13.-17.
			7.	3.	9.02 12.11	12.-16.	17.-22.
		Per Capita	3.	5.	6.54 8.66	8.-12.	12.-16
			7.	3.	9.38 12.41	13.-17.	17.-23.
Present	Delayed (Model 1)	Aggregate	3.	5.	12.47 13.57	17.-18	23.-25.
			7.	3.	14.35 15.61	19.-21.	27.-29.
		Per Capita	3.	5.	12.81 13.92	17.-19.	24.-26.
			7.	3.	15.01 16.31	20.-22.	28.-30.
	Immediate (Model 2)	Aggregate	3.	5.	12.81 13.92	17.-19.	24.-26.
			7.	3.	14.39 15.65	19.-21.	27.-29.
		Per Capita	3.	5.	13.31 14.46	18.-19.	25.-27.
			7.	3.	15.07 16.36	20.-22.	28.-30.

[a] excluding centrally planned economies.

[b] OECD did not make a forecast of NOLDC demand in 1990 (see Table A in Appendix).

Note: Projections assume a steady population increase of 2.7 percent per year, and percentage rates of GDP growth and price growth as indicated. The figures under the columns labelled WAES and Eden show our NOLDC forecasts as a percentage of the 1990 world oil consumption estimates made in those studies.

Table 4 (continued)

PERCENTAGE RANGE OF OIL DEMAND FORECASTS

4.B. Range Due to Definition of Variables

Country Dummies	Adjustment to Income Change	Dependent Variable Form	Growth Rates (%) GDP	Price	Range of Forecasts and Share World[a] Demand Mb/d	1990[b] WAES (%)	Eden (%)
Absent	Delayed (Model 1)	Aggregate	3.	5.	6.33 8.24	9. 11.	12. 15.
			7.	3.	7.89 10.41	11. 14.	15. 19.
		Per Capita	3.	5.	6.13 7.85	8. 11.	11. 15.
			7.	3.	7.76 11.04	10. 15.	14. 20.
	Immediate (Model 2)	Aggregate	3.	5.	6.03 7.83	8. 11.	11. 15.
			7.	3.	7.71 10.45	10. 14.	14. 19.
		Per Capita	3.	5.	5.73 7.53	8. 10.	11. 14.
			7.	3.	7.47 10.79	10. 15.	14. 20.
Present	Delayed (Model 2)	Aggregate	3.	5.	13.01 14.75	18. 20.	24. 27.
			7.	3.	13.98 16.51	19. 22.	26. 31.
		Per Capita	3.	5.	13.35 15.27	18. 21.	25. 28.
			7.	3.	14.57 17.31	20. 23.	27. 32.
	Immediate (Model 2)	Aggregate	3.	5.	13.25 14.64	18. 20.	25. 27.
			7.	3.	13.59 16.60	18. 22.	25. 31.
		Per Capita	3.	5.	13.68 15.24	18. 21.	25. 28.
			7.	3.	14.20 17.45	19. 24.	26. 32.

[a] excluding centrally planned economies.

[b] OECD has not made a forecast of NOLDC demand in 1990.

Note: Projections assume a steady population increase of 2.7 percent per year, and percentage rates of GDP growth and price growth as indicated.

Table 5

PERCENTAGE RANGE OF OIL DEMAND FORECASTS, BY SOURCE
AND MODEL TYPE FOR CENTRAL CASE SCENARIO
5.A. Range Due to Forecast Standard Errors

Country Dummies	Adjustment to Income Change	Dependent Variable Form	Growth Rates (%)		Range of Forecasts and Share World[a] Demand		
			GDP	Price	Mb/d	1990[b] WAES (%)	Eden (%)
Absent	Delayed (Model 1)	Aggregate	5.	5.	7.57 10.29	10. 14.	14. 19.
		Per Capita	5.	5.	7.73 10.28	10. 14.	14. 19.
	Immediate (Model 2)	Aggregate	5.	5.	7.47 10.04	10. 14.	14. 19.
		Per Capita	5.	5.	7.53 9.97	10. 13.	14. 18.
Present	Delayed (Model 1)	Aggregate	5.	5.	13.22 14.38	18. 19.	25. 27.
		Per Capita	5.	5.	13.71 14.90	18. 20.	25. 28.
	Immediate (Model 2)	Aggregate	5.	5.	13.42 14.58	18. 20.	25. 27.
		Per Capita	5.	5.	14.00 15.20	19. 20.	26. 28.

[a] excluding centrally planned economies.

[b] OECD has not made a forecast of NOLDC demand in 1990.

Note: Projections assume a steady population increase of 2.7 percent per year, and percentage rates of GDP growth and price growth as indicated.

Table 5 (continued)

PERCENTAGE RANGE OF OIL DEMAND FORECASTS, BY SOURCE
AND MODEL TYPE FOR CENTRAL CASE SCENARIO

5.B. Range Due to Definition of Variables

Country Dummies	Adjustment to Income Change	Dependent Variable Form	Growth Rates (%)		Range of Forecasts and Share World[a] Demand			
			GDP	Price	Mb/d	1990[b] WAES (%)		Eden (%)
Absent	Delayed (Model 1)	Aggregate	5.	5.	6.59 8.83	9. 12.		12. 16.
		Per Capita	5.	5.	6.43 8.92	9. 12.		12. 17.
	Immediate (Model 2)	Aggregate	5.	5.	6.36 8.66	9. 12.		12. 16.
		Per Capita	5.	5.	6.10 8.66	8. 12.		11. 16.
Present	Delayed (Model 1)	Aggregate	5.	5.	13.51 15.07	18. 20.		25. 28.
		Per Capita	5.	5.	13.99 15.66	19. 21.		26. 29.
	Immediate (Model 2)	Aggregate	5.	5.	13.24 15.32	18. 21.		25. 28.
		Per Capita	5.	5.	13.76 16.03	19. 22.		26. 30.

[a] excluding centrally planned economies.

[b] OECD has not made a forecast of· NOLDC demand in 1990.

Note: Projections assume a steady population increase of 2.7 percent per year, and percentage rates of GDP growth and price growth as indicated.

POLICY IMPLICATIONS

What policy implications follow from these major uncertainties about
NOLDC oil and energy demand in the next decade?

From the standpoint of U. S. energy policy, it may be wise to give
greater attention to the forecasts based on high NOLDC income growth, and
high income elasticity of NOLDC demand, combined with low price elasticity
of NOLDC demand. If growth rates in the NOLDCs are reasonably high
(7 percent or more) and energy price increases are low, NOLDC demand for
oil may reach or exceed 17 MB/D in 1990. This means that the oil
consumption of the NOLDCs would amount to more than 30 percent of world
consumption, and that their oil imports would be nearly 35 percent of world
imports. If rates of economic growth in the NOLDCs are at the 7 percent
annual level and world oil prices are also rising steadily, NOLDC oil
demand would still be fairly high, perhaps as high as 15 MB/D, or as much
as 27 percent of world consumption and almost 30 percent of world imports.

The range of these forecasts suggests a dilemma for U. S. policy.
Rapid growth and economic development in the NOLDCs--a general aim of U. S.
foreign policy--especially if coupled with low price elasticity and high
income elasticity of demand, will mean a rapidly growing NOLDC demand for
oil and hence upward pressure on world oil prices and supplies--a situation
that U. S. energy policy would prefer to avoid. Thus, the aims of U. S.
policy in the arena of North-South relations are in conflict with those in
the international energy arena.

In principle, reconciliation between these differing U. S. policy
interests may lie in our encouraging the NOLDCs to follow "soft energy paths"
(i.e., solar, geothermal, biomass, and other renewable energy sources) as well
as to develop fossil fuel resources. U. S. assistance that focuses on the
development of these alternatives, not excluding nuclear power, will help
to ease the conflict between U. S. energy policy and U. S. foreign policy
vis-a-vis the LDCs. But these paths contain some pitfalls. Politically, the
LDCs are likely to react with skepticism if not resentment toward the U. S.
if we try to promote soft energy development, as well as increased use of
gas and coal, in the developing countries while continuing to expand our own

oil consumption at home. Moreover, the promotion of nuclear power development in the LDCs may increase the major hazard of proliferation of nuclear weapons.

The conflict between these two dimensions of U. S. policy--energy policy, and foreign policy toward the "South"--is a real one. It may be a whimsical consolation to observe that the intensity of the conflict is likely to be eased by the limited effectiveness of U. S. policy efforts in both domains: accelerating the development of the LDCs, or restraining the international demand for oil. However, U. S. pronouncements in various international forums should at least be aware of, and sensitive to, the existence of this conflict.

The relationship between the NOLDCs and world oil markets may be viewed from a different, and more congenial, standpoint. Instead of looking at the effect of NOLDC economic growth and oil demand on world oil markets, one may consider the effect of oil markets on the NOLDCs. When viewed from this standpoint, the energy policy of the U. S. and its foreign policy are highly compatible, and, more broadly, so are the interests of the U. S. and those of the NOLDCs.

In general, the NOLDCs and the developed countries share a strong interest in expanded world oil supplies and lower, or constant, world oil prices. The developed countries and the oil-importing less-developed countries are on the same side of this North-South issue, not on opposite sides. The conventional way of viewing North-South issues tends to miss or obscure this point. From the standpoint of energy issues, the prevalence of conflicting interests may be less appropriately aligned along axes labelled "North-South" than along those labelled "South versus South," or "North-plus-NOLDC-South" versus "remainder-of-South."

For example, the 1979 oil import bill of about $31 billion paid by all NOLDCs (based on $18-per-barrel oil prices and current NOLDC imports of 4.7 MB/D) probably constitutes at least as great an impediment to more rapid economic development in the NOLDCs as any other aspects of the current (as distinct from the "new") international economic order. Moreover, these costs will probably be steadily rising over the next decade. By 1990, it is estimated that the oil import bill of the NOLDCs will be between $47 billion and $88 billion (in 1979 dollars) over the central range

of our demand forecasts.[*] Thus, the incremental costs to the NOLDCs of
their annual oil imports will almost surely be much higher than the benefits
they might plausibly receive from any of the measures of international
economic reform sought by these countries; e.g., the stabilization fund
advocated by the United Nations Conference on Trade and Development in its
Integrated Program of Commodities; or the amounts of debt-service reduction
that would ensue from a rescheduling of LDC foreign indebtedness; or the
increases in foreign economic assistance that might be obtained from the
developed countries of the North.

Of course, the cogency of this point may differ with respect to
different subgroups among the NOLDCs. The rapidly growing NICs (newly-
industrialized countries) have been able to surmount the resource burden of
drastically increased oil import costs, but most of the NOLDCs have not.
For those countries whose large and growing burden of oil import costs acts
as a brake on their economic development, the possibility that OPEC might
agree to a concessional oil price for NOLDC buyers may warrant exploration.

There are obvious and serious drawbacks to such a proposal. Moreover,
its political feasibility and acceptability are remote, at best.
Nonetheless, the idea is attractive because it just might be a means for
the NOLDCs to obtain supplementary assistance from the non-OPEC "South."
It may also provide a concrete way for the U. S., individually and together
with other countries of the "North," to collaborate with the NOLDC "South"
in furthering NOLDC interests.

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[*] The range is based on two assumptions: (1) The ratio between NOLDC oil
imports and oil consumption is assumed to be the same in 1990 as in 1976
(i.e., 0.84). (2) The minimum estimate of NOLDC oil consumption (6.1 MB/D,
Table 5) is associated with an assumed world oil price of $25 per barrel
(in 1979 prices), and the maximum estimate in Table 5 (16.0 MB/D) is
associated with an assumed oil price of $18 per barrel. It seems likely that
these estimates are conservative; the actual figures are more likely to

Appendix

Table A

FORECASTS OF ENERGY CONSUMPTION FOR NOLDCs: 1980, 1985, 1990
(in MB/D oil equivalent)

Source of Forecast	1980	1985	1990
Commercial Energy Consumption			
OECD[a]	11.3 (11.9%)	15.0 (12.8%)	--
WAES[b]	11.6-12.6 (10.7-11.6%)	14.6-17.8 (11.8-14.4%)	18.0-22.5 (12.1-15.2%)
Energy Research Group (Eden)[c]	20.0 (19.8%)	22.8 (20.5%)	27.0 (21.0%)
World Bank (Lambertini)[d]	11.2-11.4	13.3	16.9
World Bank (Choe)[e]	12.2	16.8-17.4	18.9-24.9
Oil Consumption			
OECD	5.3 (10.8%)	6.2 (10.9%)	--
WAES	7.5-8.3 (13.9-15.2%)	9.5-10.7 (15.0-16.9%)	11.7-13.5 (15.8-18.2%)
Energy Research Group (Eden)	9.0 (19.0%)	11.4 (21.4%)	13.3 (24.5%)
World Bank (Lambertini)	6.2-6.8	7.8	10.0

NOTE: Figures in parentheses show the corresponding shares of world consumption of commercial energy and oil, respectively, based on forecasts presented in each of the studies referred to below.

[a] Organization for Economic Cooperation and Development, *World Energy Outlook*, Paris, 1977.

[b] Workshop on Alternative Energy Strategies, *Energy: Global Prospects, 1985-2000*, The M.I.T. Press, Cambridge, Mass., 1977. The range of the WAES forecasts results from varying assumptions about changes in prices and income. Oil consumption forecasts for 1990 have been derived by applying the WAES income elasticity for commercial energy consumption to the WAES estimate of oil consumption in 1985.

[c] Energy Research Group (Cambridge), R. Eden et al., *Report on Energy Demand, 1975-2000*, 1977.

[d] World Bank, A. Lambertini, *Energy and Petroleum in Non-OPEC Developing Countries, 1974-1980*, World Bank Staff Working Paper No. 229, Washington, D.C., 1976. Lambertini's forecasts for 1980 were extended to 1985 and 1990 by Gordian Associates, *Requirements for Financing Energy Development in Non-OPEC Less-Developed Countries through 1990*, 1976.

[e] World Bank, B. J. Choe, *Energy Demand Prospects in Non-OPEC Developing Countries*, 1978. The Choe estimates are based on a panel of 35 developing countries. He extends these estimates to the NOLDCs as a whole by assuming a constant ratio between energy demand in all NOLDCs and his country panel. In 1975 that ratio was 1.23 [=(9.67 MB/D)/(7.87 MB/D)]. Choe's original estimates reached to 1985. We have projected them to 1990 by using his price and income elasticities (for upper-middle-income and lower-income NOLDCs), and the two differing price and income scenarios that he postulates. One scenario assumes a price increase of 15 percent and a gross-domestic-product (GDP) growth of about 30 percent over the 1980-1985 period. The second scenario assumes no price increase, but the GDP growth rate is maintained. Choe does not make separate forecasts for oil.

APPENDIX

Table B

REGRESSION STATISTICS FOR AGGREGATE NOLDC OIL AND ENERGY DEMAND

Dummy Variables and Variable Definitions[a]	Regression Coefficients				t-Statistics[b]				Standard Error	R^2
	Q(t-1)	P(t)	Y(t)	Y(t-1)	Q(t)	P(t)	Y(t)	Y(t-1)		
Oil Demand										
[2]	0.976	-0.055	0.029	0.0	127.17	-4.99	3.37	0.0	0.133	0.9940
	0.978	-0.043	0.030	0.0	124.88	-4.17	3.43	0.0	0.134	0.9939
	0.976	-0.049	0.180	-0.153	127.71	-4.39	3.11	-2.66	0.131	0.9941
[2]	0.978	-0.039	0.197	-0.169	125.66	-3.80	3.40	-2.94	0.132	0.9941
[1]	0.458	-0.071	0.117	0.0	12.14	-3.62	3.23	0.0	0.108	0.9960
[1,2]	0.466	-0.049	0.117	0.0	12.28	-3.07	3.19	0.0	0.109	0.9960
[1]	0.462	-0.072	0.180	-0.090	12.19	-3.71	3.36	-1.50	0.108	0.9960
[1,2]	0.470	-0.050	0.178	-0.087	12.31	-3.14	3.28	-1.43	0.109	0.9960
[3]	0.986	-0.059	0.017	0.0	178.49	-5.32	3.10	0.0	0.133	0.9940
[2,3]	0.988	-0.047	0.017	0.0	175.83	-4.52	3.10	0.0	0.134	0.9939
[3]	0.986	-0.059	0.071	-0.055	179.19	-5.37	2.71	-2.14	0.132	0.9941
[2,3]	0.988	-0.047	0.069	-0.052	176.69	-4.64	2.60	-2.01	0.133	0.9940
[1,3]	0.481	-0.076	0.013	0.0	12.91	-3.82	0.85	0.0	0.109	0.9959
[1,2,3]	0.490	-0.054	0.012	0.0	13.08	-3.31	0.78	0.0	0.110	0.9959
[1,3]	0.484	-0.072	0.053	-0.054	13.02	-3.62	2.23	-2.20	0.108	0.9960
[1,2,3]	0.493	-0.050	0.053	-0.056	13.18	-3.11	2.22	-2.25	0.109	0.9960
Total Energy Demand										
	0.974	-0.041	0.030	0.0	133.67	-4.15	3.42	0.0	0.133	0.9948
[2]	0.974	-0.037	0.031	0.0	129.70	-3.80	3.42	0.0	0.135	0.9946
	0.97?	-0.037	0.178	-0.148	133.67	-3.74	3.24	-2.72	0.132	0.9948
[2]	0.973	-0.034	0.188	-0.157	129.72	-3.48	3.33	-2.81	0.135	0.9947
[1]	0.564	-0.061	0.131	0.0	17.19	-3.10	3.89	0.0	0.113	0.9962
[1,2]	0.556	-0.060	0.137	0.0	16.56	-3.67	3.86	0.0	0.114	0.9962
[1]	0.554	-0.062	0.144	-0.011	16.77	-3.19	2.76	-0.19	0.112	0.9963
[1,2]	0.544	-0.061	0.131	0.016	16.07	-3.78	2.44	0.27	0.113	0.9963
[3]	0.985	-0.045	0.016	0.0	190.09	-4.47	2.81	0.0	0.133	0.9947
[2,3]	0.986	-0.040	0.016	0.0	185.82	-4.13	2.79	0.0	0.136	0.9946
[3]	0.984	-0.046	0.066	-0.050	189.47	-4.56	2.51	-1.95	0.133	0.9947
[2,3]	0.985	-0.041	0.065	-0.049	185.24	-4.22	2.43	-1.87	0.136	0.9946
[1,3]	0.586	-0.065	0.010	0.0	17.91	-3.23	0.68	0.0	0.114	0.9961
[1,2,3]	0.578	-0.064	0.009	0.0	17.22	-3.85	0.59	0.0	0.115	0.9961
[1,3]	0.575	-0.060	0.056	-0.059	17.74	-3.03	2.30	-2.42	0.013	0.9962
[1,2,3]	0.567	-0.061	0.052	-0.056	17.04	-3.69	2.11	-2.26	0.114	0.9962

NOTE: The letters at top of columns are as defined in the text: Q = oil (energy) demand; P = oil (energy) price); Y = income (GDP); t = year.

[a]The following explanation applies to the numbers shown in this column: [1] signifies that country dummy variables were used in the regression equation whose coefficients appear in the adjacent row to the right; [2] signifies that "own-price" (P_t'') was used to measure oil or energy prices (where [2] does not appear, deflated Ras Tanura prices were used); [3] signifies that income (GDP) was measured by $Y_{i,t}'$ (with the U.S. price deflator); where [3] does not appear, the measure of income used is Y_t with deflation by the local price deflator . Thus, where [2,3] appears at the left, the adjacent regression equation (a) did *not* use country dummies, (b) defined the price variable as P", and (c) defined the income variable as Y_t'.

The model (2) regression estimates are those in which Y_{t-1} appears; the other coefficients refer to model (1).

Seventy-seven NOLDCs are included in the analysis.

[b]Formal tests of serial correlation, such as the Durbin-Watson test, were not applied to our data. We did not think they were necessary for the models with dummy variables, since such models would correct for any error components that were constant within countries. For the models without dummies, we examined plots of residuals within each country (while looking for outliers), to confirm that there were no apparent trends in the residuals.

APPENDIX

Table C

REGRESSION STATISTICS FOR PER CAPITA NOLDC OIL AND ENERGY DEMAND

Dummy Variables and Variable Definitions[a]	Regression Coefficients				t-Statistics[b]				Standard Error	R^2
	Q(t-1)	P(t)	Y(t)	Y(t-1)	Q(t)	P(t)	Y(t)	Y(t-1)		
Oil Demand										
	0.966	-0.054	0.055	0.0	108.45	-4.86	3.81	0.0	0.134	0.9903
[2]	0.965	-0.041	0.059	0.0	107.21	-4.07	4.05	0.0	0.136	0.9902
	0.970	-0.047	0.234	-0.192	109.52	-4.19	4.17	-3.30	0.133	0.9906
[2]	0.970	-0.037	0.249	-0.205	108.53	-3.63	4.43	-3.50	0.134	0.9905
[1]	0.431	-0.073	0.144	0.0	11.48	-3.71	4.09	0.0	0.109	0.9937
[1,2]	0.440	-0.050	0.143	0.0	11.65	-3.06	4.01	0.0	0.110	0.9936
[1]	0.439	-0.075	0.226	-0.121	11.57	-3.82	4.40	-2.12	0.108	0.9938
[1,2]	0.449	-0.050	0.226	-0.124	11.74	-3.16	4.35	-2.12	0.109	0.9937
[3]	0.986	-0.059	0.020	0.0	182.43	-5.23	2.86	0.0	0.135	0.9902
[2,3]	0.988	-0.045	0.021	0.0	180.15	-4.36	2.97	0.0	0.137	0.9901
[3]	0.986	-0.059	0.090	-0.071	183.42	-5.31	3.42	-2.75	0.134	0.9904
[2,3]	0.988	-0.046	0.087	-0.067	181.20	-4.49	3.28	-2.57	0.135	0.9903
[1,3]	0.458	-0.081	0.028	0.0	12.30	-4.03	1.79	0.0	0.110	0.9935
[1,2,3]	0.468	-0.056	0.026	0.0	12.50	-3.41	1.67	0.0	0.111	0.9935
[1,3]	0.463	-0.077	0.070	-0.057	12.41	-3.84	2.94	-2.32	0.109	0.9936
[1,2,3]	0.473	-0.053	0.070	-0.059	12.61	-3.23	2.92	-2.40	0.110	0.9936
Total Energy Demand										
	0.965	-0.041	0.056	0.0	115.91	-4.04	4.05	0.0	0.135	0.9908
[2]	0.964	-0.036	0.061	0.0	112.63	-3.73	4.27	0.0	0.137	0.9906
	0.969	-0.036	0.231	-0.188	116.04	-3.54	4.32	-3.39	0.134	0.9909
[2]	0.967	-0.032	0.242	-0.195	112.91	-3.33	4.41	-3.41	0.136	0.9907
[1]	0.541	-0.065	0.146	0.0	16.38	-3.27	4.45	0.0	0.114	0.9934
[1,2]	0.534	-0.061	0.155	0.0	15.79	-3.69	4.47	0.0	0.115	0.9934
[1]	0.536	-0.066	0.201	-0.073	16.03	-3.36	4.00	-1.30	0.113	0.9935
[1,2]	0.527	-0.062	0.196	-0.053	15.38	-3.79	3.78	-0.92	0.114	0.9935
[3]	0.986	-0.045	0.019	0.0	188.32	-4.38	2.65	0.0	0.136	0.9906
[2,3]	0.987	-0.040	0.020	0.0	184.13	-4.04	2.76	0.0	0.139	0.9904
[3]	0.985	-0.045	0.086	-0.069	187.90	-4.46	3.27	-2.65	0.136	0.9907
[2,3]	0.986	-0.041	0.086	-0.067	183.67	-4.11	3.19	-2.53	0.138	0.9905
[1,3]	0.565	-0.071	0.022	0.0	17.11	-3.53	1.44	0.0	0.115	0.9932
[1,2,3]	0.558	-0.067	0.020	0.0	16.47	-3.98	1.33	0.0	0.117	0.9932
[1,3]	0.555	-0.067	0.075	-0.068	16.95	-3.34	3.07	-2.78	0.114	0.9934
[1,2,3]	0.548	-0.063	0.071	-0.065	16.31	-3.81	2.88	-2.63	0.115	0.9934

NOTE: The letters at top of columns are as defined in the text: Q = oil (energy) demand; P = oil (energy price); Y = income (GDP); t = year.

[a]The following explanation applies to the numbers shown in this column: [1] signifies that country dummy variables were used in the regression equation whose coefficients appear in the adjacent row to the right; [2] signifies that "own-price" (P_t'') was used to measure oil or energy prices (where [2] does not appear, deflated Ras Tanura prices were used); [3] signifies that income (GDP) was measured by $Y_{i,t}'$ (with the U.S. price deflator); where [3] does not appear, the measure of income used is Y_t with deflation by the local price deflator instead. Thus, where [2,3] appears at the left, the adjacent regression equation (a) did *not* use country dummies, (b) defined the price variable as P", and (c) defined the income variable as Y_t'.
The model (2) regression estimates are those in which Y_{t-1} appears; the other coefficients refer to model (1).

[b]Formal tests of serial correlation, such as the Durbin-Watson test, were not applied to our data. We did not think they were necessary for the models with dummy variables, since such models would correct for any error components that were constant within countries. For the models without dummies, we examined plots of residuals within each country (while looking for outliers), to confirm that there were no apparent trends in the residuals.

APPENDIX

Table D

RANGE OF INCOME ELASTICITIES RESULTING FROM MODEL VARIATIONS[a]

Country Dummy Variables	Adjustment to Income Change	Short-Run Income Elasticity[b]		Medium-Run Income Elasticity[c]		Long-Run Income Elasticity[d]		Income Elasticity Realized by 1990[e]	
		Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
		D1. Oil Demand: 77 NOLDCs							
Absent	Delayed; model (1)	0.017	0.059	0.621	0.881	1.225	1.715	0.217	0.663
	Immediate; model (2)	0.069	0.249	0.641	0.871	1.154	1.636	0.259	0.653
Present[f]	Delayed; model (1)	0.012	0.144	0.018	0.200	0.024	0.256	0.024	0.256
	Immediate; model (2)	0.053	0.226	0.024	0.206	-0.005	0.187	-0.005	0.187
		D2. Total Energy Demand: 77 NOLDCs							
Absent	Delayed; model (1)	0.016	0.061	0.524	0.878	1.033	1.696	0.200	0.677
	Immediate; model (2)	0.065	0.242	0.538	0.851	1.010	1.459	0.245	0.670
Present[f]	Delayed; model (1)	0.009	0.155	0.015	0.244	0.022	0.332	0.022	0.332
	Immediate; model (2)	0.052	0.201	0.021	0.248	-0.009	0.324	-0.009	0.324

[a]The figures shown in Tables D1 and D2 cover the intervals between minimum and maximum values resulting from model variations described in the text. For oil demand, variations in the models cover aggregate and per capita demand (consumption), as well as the differing definitions of income and price variables described above. For total energy demand, model variations cover the same items, but the only price variable used is the Ras Tanura price in constant 1970 dollars.

[b]Figures show the range of the regression estimates for the combined parameters $\alpha(1 - \lambda)$ in model (1), and for the parameter α_1 in model (2). All coefficients for the oil regressions (Table D1) are statistically significant at a level of 2.5 percent or less. For the total energy regressions (Table D2), the only coefficient not significantly different from zero is the minimum short-run elasticity shown for model (1), 0.016. All other short-run elasticities are significant at a 5-percent level or less.

[c]Calculated as the arithmetic average of the short-run and long-run income elasticities. (See A. Lambertini, *Energy and Petroleum in Non-OPEC Developing Countries, 1974-1980*, World Bank Staff Working Paper No. 229, Washington, D.C., 1976, p. 6.)

[d]Calculated by dividing the short-run income elasticity, in model (1), by $(1 - \lambda)$. For model (1), α is the long-run elasticity. For model (2), $(\alpha_1 + \alpha_2)/(1 - \lambda)$ is the long-run elasticity (see footnote e below).

[e]Defined as the predicted percentage change in the 1990 demand resulting from an income change of 1 percent in 1977, with constant income, as well as price, thereafter. The figures shown in Tables D1 and D2 are calculated recursively. For model (1), the estimated parameter values for α, β, and λ are used, together with the assumed initial percentage increase in income, to calculate oil demand in period t. The demand is then used, with the same parameter values, to calculate demand in t + 1, and so on. Recursive estimation of the specification shown for model (2) results in a realized income elasticity, after n years, given by the following expression: $(\alpha_1 + \alpha_2)(1 - \lambda^n)/(1 - \lambda) - \alpha_2\lambda^{n-1}$, where α_2 is the coefficient of the lagged income variable as discussed in the text. As n approaches infinity, this elasticity expression reduces to $(\alpha_1 + \alpha_2)/(1 - \lambda)$. The elasticities shown for 1990 are calculated from the year 1977; hence, n = 13.

[f]A time-trend variable is included in these models.

Appendix

Table E

RANGE OF PRICE ELASTICITIES RESULTING FROM MODEL VARIATIONS[a]

Country Dummy Variables	Adjustment to Income Change	Short-Run Price Elasticity[b]		Medium-Run Price Elasticity[c]		Long-Run Price Elasticity[d]		Price Elastici Realized by 199	
		Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximu
		E1. Oil Demand: 77 NOLDCs							
Absent	Delayed; model (1)	-0.059	-0.041	-2.189	-0.620	-4.320	-1.199	-0.756	-0.467
	Immediate; model (2)	-0.059	-0.037	-2.185	-0.637	-4.311	-1.237	-0.761	-0.427
Present[f]	Delayed; model (1)	-0.081	-0.049	-0.115	-0.069	-0.149	-0.089	-0.149	-0.089
	Immediate; model (2)	-0.077	-0.050	-0.110	-0.071	-0.143	-0.092	-0.143	-0.092
		E2. Total Energy Demand: 77 NOLDCs							
Absent	Delayed; model (1)	-0.045	-0.036	-1.629	-0.528	-3.213	-1.020	-0.572	-0.407
	Immediate; model (2)	-0.046	-0.032	-1.541	-0.512	-3.037	-0.992	-0.577	-0.370
Present[f]	Delayed; model (1)	-0.071	-0.060	-0.118	-0.096	-0.164	-0.130	-0.164	-0.130
	Immediate; model (2)	-0.067	-0.060	-0.108	-0.096	-0.150	-0.131	-0.150	-0.130

[a]The figures shown in Tables E1 and E2 cover the intervals between minimum and maximum values resulting from model variations described in the text. For oil demand, variations in the models cover aggregate and per capita demand (consumption), as well as the differing definitions of income and price variables described above. For total energy demand, model variations cover the same items, but the only price variable used is the Ras Tanura price in constant 1970 dollars.

[b]Figures show the range of the regression estimates for the combined parameters $\beta(1 - \lambda)$ in models (1) and (2). When the country dummy variables are absent, all of the short-run (negative) elasticity coefficients are significant at the .005 level, for both the oil regressions (Table E1), and the total energy regressions (Table E2).

[c]Calculated as the arithmetic average of the short-run and long-run price elasticities. (See A. Lambertini, *Energy and Petroleum in Non-OPEC Developing Countries, 1974-1980*, World Bank Staff Working Paper No. 229, Washington, D.C., 1976)

[d]Calculated by dividing the short-run price elasticity, in model (1), by $(1 - \lambda)$. For model (1), β is the long-run elasticity.

[e]Defined as the predicted percentage change in the 1990 demand resulting from a price change of 1 percent in 1977, with constant prices, as well as income, thereafter. The figures shown in Tables E1 and E2 are calculated recursively, as described in footnote e to Table D.

[f]A time-trend variable is included in the models.